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RESEARCH PAPER

Study Antibacterial Activity of Sliver Nanoparticles Synthesis by Fenugreek Seed Extract against Resistant Vibrio cholerae Isolated from Owner of Birds

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ABSTRACT

The biosynthesis of AgNPs by using *Trigonella foenum-graecum* seed extract act as the reducing agents and have antibacterial activity,This research work was designed to evaluate the antibacterial effect of (AgNPs) and synergestic effect with antibiotic on resistant *V.cholerae* isolate. Synthesis of AgNPs by using fenugreek seeds and Characterization were diagnosed by UV-Visible spectroscopy,Fourier-transform infrared spectroscopy (FTIR), Scanning electron microscope (SEM) Transmission electron microscopy (TEM), X-ray diffraction and Evaluation of synergistic AgNPs in combination with antibiotic in well diffusion assay. The appearance of a dark brown colour in the solution indicates the presence of Ag NPs. The AgNPs characterized by UV peak appear at 450nm., TEM images showed nanoparticles spherical shape, size (10-50) nm, SEM showed size ranged between (26.87-47.93) nm. The FTIR with different distinct (7) peaks, in XRD the average was 17.86 nm. the synergistic of AgNPs with antibiotic in well assay showed that the antibiotic became more effective on *V.cholerae*. In Conclusion**:** AgNPs were effectively act as antibacterial against *V.cholerae* and using fenugreek seeds extract is considered better antibacterial regarded the low cost product and eco-friendly in AgNPs synthesis.

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INTRODUCTION

Cholera, an acute diarrheal disease caused primarily by consumption of water or food containing *V. cholerae* [1,2] *V.cholerae* comma-shaped rod bacteria with polar flagella wrapped in a sheath, gram-negative and halophilic [3-5] Nanoparticles a cluster of atoms having a large surface area with width littler than 100 nm and are used in various applications including drug delivery. Antimicrobial lactivity, food industry [6-8]. Silver nanoparticles (AgNPs) a substances capable of suppressing microorganism activity act as antimicrobial, anti-inflammatory antioxidant and anticancer [9-11]. Plant extracts act as reducing agents in AgNPs synthesis and capping agents Alternative types of plant extracts have been reported in the literature for green synthesis. [12-14]. Fenugreek seeds El Helba, are known in ancient before 2500 years ago is one of the important spices with various health

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benefits widely grown in Pakistan, India, Egypt, and Middle Eastern countries and it is one of the medical plants that has been reported for various pharmacological activities contain L-tryptophan, lysine-, mucilaginous fiber, saponins, coumarin, fenugreekine, nicotinic acid, phyticacid, scopoletin, and trigonelline. [15-17]. Other constituents are vitamins flavonoids, alkaloids, and amino acids, alkaloids fenugreek effects as anti-cancer drugs, hormones, antihypertensiv, hypolipidemic, hypoglycemic, hyperinsulinemic, ant diuretic effects, antinociceptive, anti-inflammatory, properties. dyspepsia, bronchial asthma and antitussive other uses in cook as flavoring agents [18,19]. Extract of the fenugreek seeds act as antioxidant interaction between NPS and plant cells change biochemical reaction [20]. The main objective of currentt investigation is to focuses on synthesize AgNPs by biological method using aqueous seeds extract of Fenugreek and study antibacterial effect.

MATERIALS AND METHODS

Preparation of Fenugreek seed extract

To prepare extract 20 g of seeds, grinding, boiled in 200 ml D.W /15 minutes, kept at room temperaturefor 24 hrs then filteration with filter paper. The seed extract was stored at 40 °C [21].

Synthesis of Silver Nitrate solution

Solution prepared by dissolving 8.49 g of $AgNO_3$ in 500 ml D.W, at room temperature for about 30 minutes under magnetization [21].

Synthesis of nanoparticles

Fenugreek extract 15 ml add to 135 ml solution of silver nitrate to make final volume 150 ml were kept in Shaking incubator for about 24 hrs at 30C.change in color of the solution from pale yellow to reddish brown took place indicating the formation of silver nanoparticles. Silver nanoparticles solution was centrifuged at 15,000 rpm for 30 minutes. The pellets obtained washed by deionized sterile water for 3 times discarded supernatant.the pellets obtained were dried 65°C [22].

Characterization of biosynthesized AgNPs

UV-Vis spectroscopy analysis

Measurements the optical Absorbance spectra of the AgNPs were performed by suspending the nanoparticles indeionized water then sonicated for 15 minutes transferred the suspention to a quartz cuvette cell. the visual observation of changing in color of fenugreek extract after treatment with silver nitrate mean detection of AgNPs by appearance of the dark brown which indicating the formation of silver nanoparticles due to reduction of pure silver ions, scanning the absorbance spectra in 400–700nm range of wavelength at a resolution of 1nm [23].

Fourier Transform Infrared Spectroscopy (FTIR)

The interaction between biomolecules and biosynthesized SNPs was analyzed using FTIRspectrophotometer in the rangeof 750-4000 cm^{-1}. Interaction responsible for capping, reduction, and stabilization of the SNPs. powder samples were mixed with the binding agent (KBr) and put into discs at high pressure, then discs were scanned to obtain the FTIR spectra [24].

Scanning Electron Microscope (SEM)

SEM used electron beam, with small probe by lenses restored across the nanomaterials. interactions with surface of sample, lead to emission of electrons penetration of nanoparticles into surface. These emitted electrons collected by a detector on monitor to give information about shapes and measure dimensions nanomaterial [25].

Transmission Electron Microscopy (TEM)

The shape, crystal structure and size of particles are shown by TEM. Analysis was done by put a drop in suspension of sliver nanoparticles on a copper grid coated with carbon then water evaporate within a vacuum dryer [26].

X-ray diffraction (XRD) measurement

XRD was done by applying drop of nanoparticles suspension to the well plate dried on a glass substrate until the well plate's surface was covered in a uniform coating of particles. Reordering Diffraction signal intensity was done by using Diffract Plus. Scherer's, equation used for calculation of grains size from the width of the XRD planes [27].

Inoculum preparation of V. cholerae isolate

V.cholerae colonies was suspending in 5 ml of sterile normal saline shaking vigorously by using a vortex mixer for about 15 second. The turbidity of suspension was adjusted to 0.5 McFarland's

standards. These suspensions were further diluted to obtain a final concentration of inoculum (1.5 ×10^5cell/ml [28].

Preparation of Stock Solution

A stock solution of silver nanoparticles and Antibiotic stock solution was made by combining 10 milliliters of distilled water (1000µg/ml) with 0.1 milligrams of AgNPs Subsequently, distinct concentrations were created by combining distilled water with a specified volume from the stock solution. Antibiotic stock solution

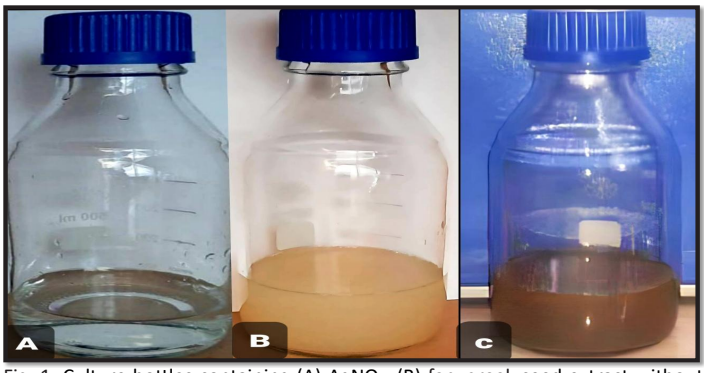

Fig. 1. Culture bottles containing (A) $AgNO_3$, (B) fenugreek seed extract without $AgNO_3$ and (c) Mixture of fenugreek seed extract with 1Mm $AgNO_3$ after incubation for 24hrs.

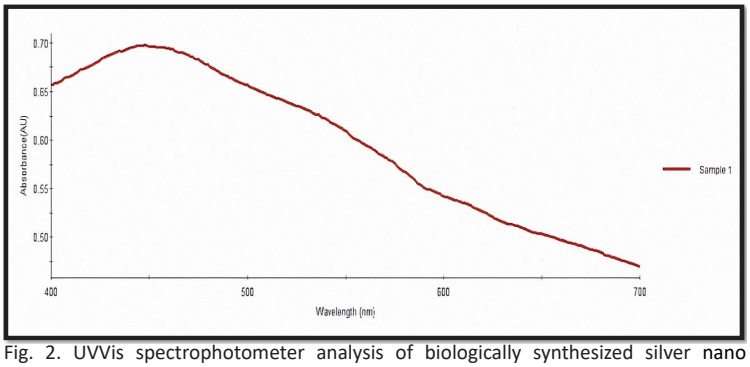

Fig. 2. UVVis spectrophotometer analysis of biologically synthesized silver nano particles of Trigonell foenum-graecum extract.

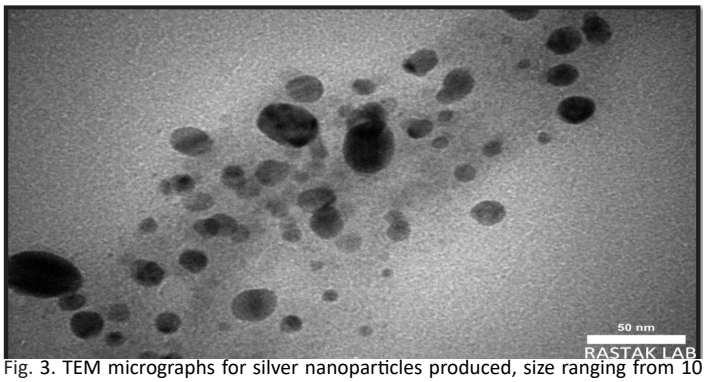

Fig. 3. TEM micrographs for silver nanoparticles produced, size ranging from 10 to 50 nm

was made by combining 0.1mg of (Gentamicin, Trimethoprim, Ceftazidime, Cefepime, Ampicillin, levofloxacin) with 10 ml of D.W (1000mg/ml). Then different Concentrations were created by combining distilled water with a known volume of the stocksolution [29,30].

Evaluation of synergistic potential of biosynthesized AgNPs in combination with antibacterial agents

In this study, the enhancement of antibacterial activity of antibiotics with AgNPs was investigated by using well diffusion method. 0.1 ml of *V.cholerae* strain was swabbed on the surface of Muller Hinton plates and after plate dried well of 5 mm created on surface agar by using of sterilized pasture pipette end. The wells were loaded with 100 µL of freshly prepared AgNPs, 100 µL of each antibiotic with a specific potency, and 100 µL of each antibiotic in combination with AgNPs (50 µL of antibiotic + 50µL of freshly prepared AgNPs solution). Wells contained D.W. and plant extract were considered as control. All these assays performed in triplicate. plates were incubated at 37 ºC for 24hr. At the end of incubation time, the diameters of inhibition zone around the wells were measured and the mean value was expressed in millimeters. Criteria of sensitivity and resistance of antibacterial agents were recorded according

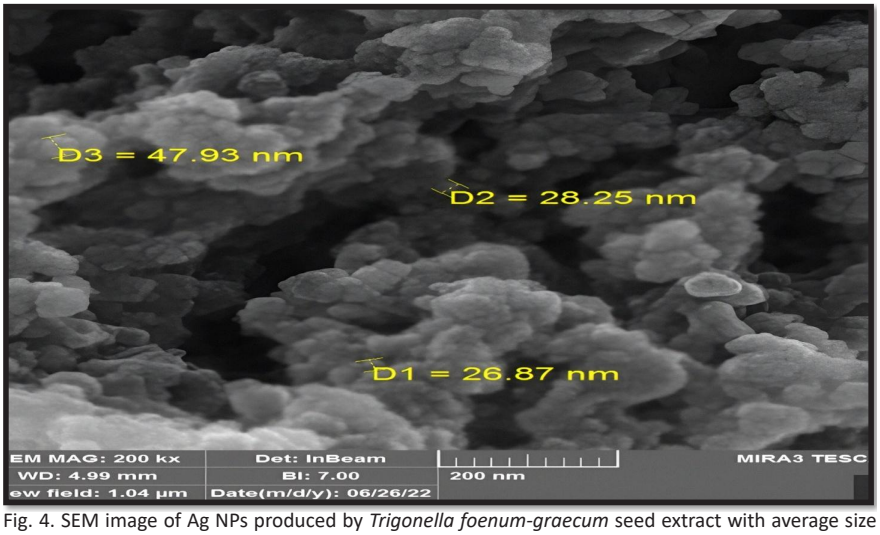

Fig. 4. SEM image of Ag NPs produced by *Trigonella foenum-graecum* seed extract with average size ranges between 26.87-47.93nm.

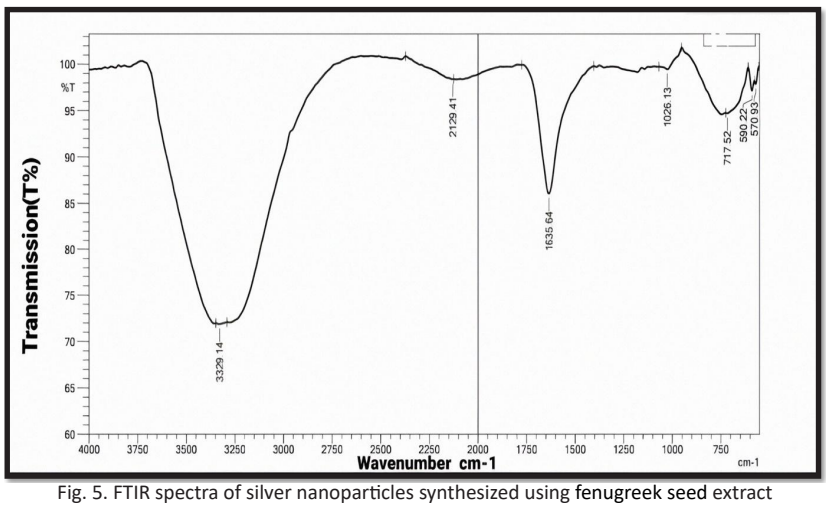

Fig. 5. FTIR spectra of silver nanoparticles synthesized using fenugreek seed extract

to [31]. Estimation of fold area was evaluated by calculating the inhibition zone produced by the antibacterial agent alone and in combination with biosynthesized SNPs [32].

Statistical Analysis

The Statistical analysis was detected the difference factors in study parameters (ANOVA) to significant compare between means [33].

RESULT AND DISCUSION

Characterization of silver Nanoparticles

Silver nanoparticles were created when $AgNO_3$ solution and seed extract were combined, the mixture's color initially changed from yellowish to brown after 1 hour. The color's intensity then increased with the prolonged period of incubation, and after 24 hours. when the reaction with Ag+ ions was complete, the color changed to dark brown. The test color changed, which is a definite sign that AgNPs were forming in the reaction mixture as in (Fig. 1). AgNPs by UV characterized at prominent peak 450nm the range of AgNPs (Fig. 2). TEM images showed surface appearance and the morphological properties of AgNPs nanoparticles spherical shape, size (10-50) nm (Fig. 3). SEM charact erized by showed spherical small size the average size of the nanoparticles ranged between

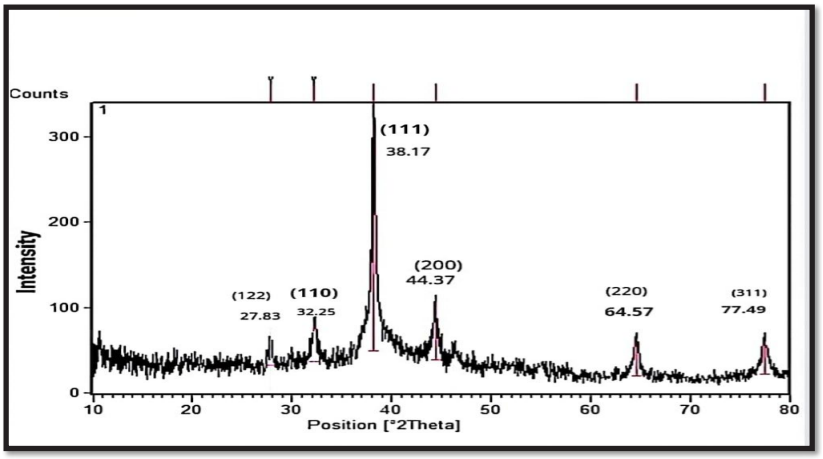

Fig. 6. XRD patterns of Silver Nanoparticles synthesized by fenugreek seed extract with $AgNO_3$ aqueous solutions.

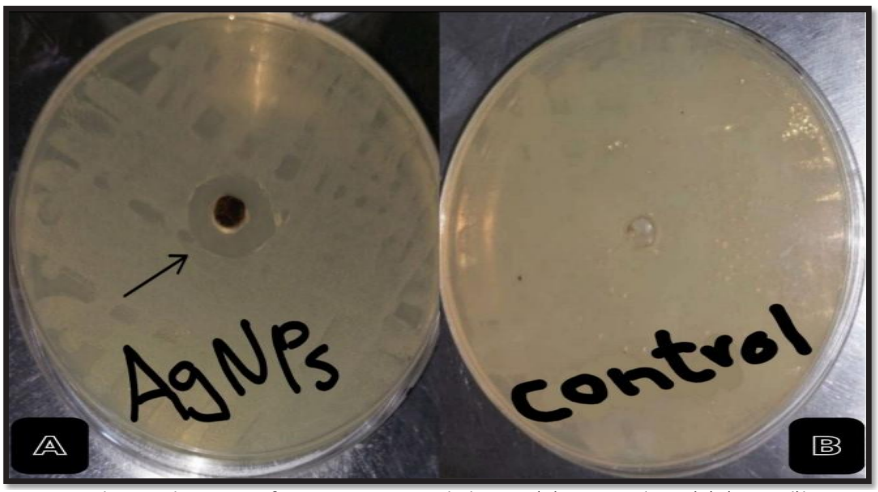

Fig. 7. Antibacterial activity of AgNPs against *V.cholerae* : (A) AgNPs alone (B) (Control)by using deioniozed water.

26.87-47.93 nm (Fig. 4). The FTIR functional groups appearas peaks in the FTIR Spectra in the Fig. 5. In XRD the average silver nanoparticle particle size, which was found in this study to be 17.86 nm (Fig.6).

The present finding in UV-Vis spectrophotometer can be attributed due to excitation of free electrons this agree with many studies that reported the absorbance peak of biosynthesized AgNps from Trigonella foenum graecum seed extract was observed at 450nm. [34,35]. This result of TEM and SEM agreed with results of [36-38]. In the FTIR functional groups Similar findings were found in many studies that used seed extract as the source of silver nanoparticles [39,40].

Evaluation of synergistic potential of biosynthesized AgNPs in combination with antibacterialagents

The synergistic effect of synthesized AgNPs combined with 6 antibiotic was evaluated by measuring the diameter of the inhibitory zone around the conventional anti bacterial drugs against *V.cholerae* using standard well diffusion method. According to the results obtained by the susceptibility test of the standard antibacterial alone, *V.cholerae* was resistant to Ampicillin,

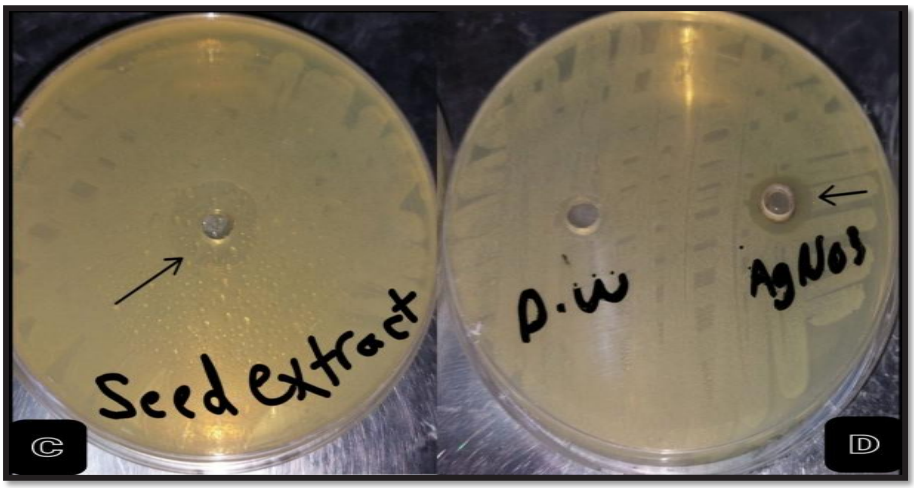

Fig. 8. (C) Antibacterial activity of *Trigonella Foenum Graecum* Seeds extract against *V.cholerae* (D) Antibacterial activity of deioniozed water and $AgNO_3$.

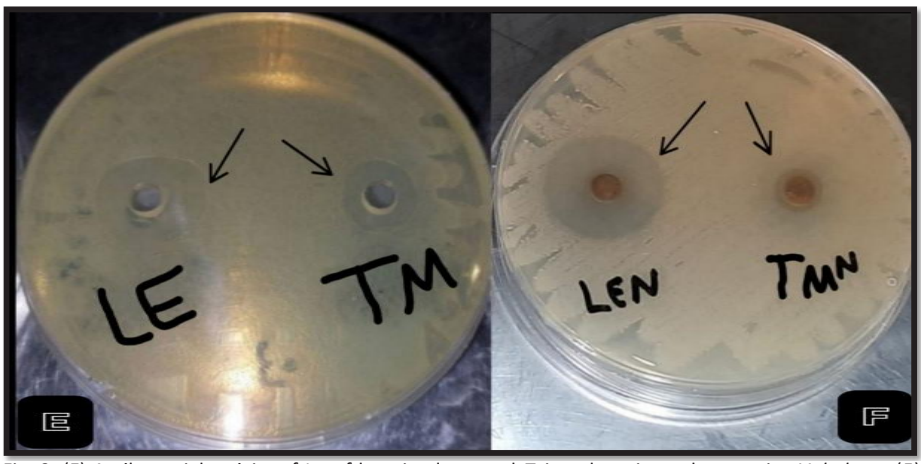

Fig. 9. (E) Antibacterial activity of Levof loxacin alone and Trimethoprime alone against*V.cholerae* (F) Antibacterial activity of AgNPs, against *V.cholerae* and their synergistic effect SNPs+ Levofloxacin (LEN) and SNPs + Trimethoprime(TMN).

Gentamicin, Ceftazidime, Cefepime, Trimethoprim, and susceptible to Levofloxacin. Thebiosynthesized AgNPs alone exerted significant activity against *V.cholerae* resulted in formation of varying zone of inhibition of *V.cholerae* which showed an inhibitory zone diameter of 18 mm. (Fig. 7). Inhibition zones were observed when they *Trigonella Foenum Graecum* Seeds extract was used and recorded 14 mm for tested *V.cholerae* and No inhibition zones were observed when deioniozed water was used, while the inhibitory zone diameter of 12mm was recorded in case of $AgNO_3$ as in Fig. 8. The synergistic activities of AgNPs in the presence of antibiotic showed effectiveness against *V.cholerae* and mostly enhanced the antibacterial effect against.*V.cholerae*. The inhibition zone of Levofloxacin alone 17 mm and when synergestic with AgNPs become 24mm and Trimethoprim alone 10mm with synergestic become 15mm as as in Fig. 9. Also, Ceftazidime alone (12 mm), with AgNPs become 16mm, Cefepime alone 14mm and with synergestic 20mm as in Fig. 10 while Ampicillin alone (12mm) with synergestic (20mm), Gentamicin alone 10mm withsynergestic 15mm as in Fig. 11. The comparison between the inhibitory effects of antibiotic alone and combination with

Fig. 10. (G) Antibacterial activity of cefepime alone and ceftazidime alone against *V.cholerae* (H) Antibacterial activity of AgNPs, against *V.cholerae* and their synergistic effect SNPs +Cefepime (FEPN) and SNPs +Cef tzidime (CAZN).

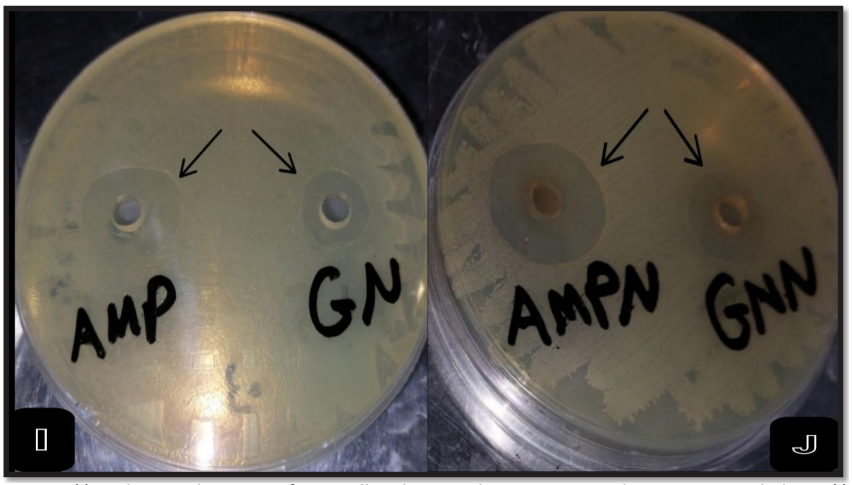

Fig. 11. (I)Antibacterial activity of Ampicillin alone and Gentamicin alone against *V.cholerae.(*J) Antibacterial activity of AgNPs, against *V.cholerae* and their synergistic effect SNPs + Ampicillin (AMPN) and SNPs + Gentamicin (GNN).

SNPs against *V.cholerae* as zone of inhibition as shown in Table 1.

The presence of *V.cholerae* in birds suggested a zoonosis important, Infection occurs while birdsare feeding in areas that have been contaminated by humans or animals, and they may spread this pathogenic organism to other areas [41-45]. Research interests nanoparticles as antibacterial agents have a wide variety of harmful effects on microbes nanoparticles are more germicidal than silver metal in terms of mass. nanoparticles have a ability to adhere and penetrate bacterial membranes and accumulate inside cells, releasing silver ions continuously inside the cell [46-48]. In comparison to the standard antibacterial agents which are frequently used in the treatment of Vibriosis such as Ampicillin, Gentamicin, Ceftazidime, Cefepime, Trime thoprim and Levofloxacin, the AgNPs exhibited variable effects. The significant differences were demonstrated between AgNPs, Levofloxacin and plant extract, this implies that AgNPs have a strong antibacterial effect. Which was significantly higher than Levofloxacin and plant extract while this isolate of *V. Cholerae* was resistant to other antibacterial drug used in this study. Many studies proved the increase of resistance of *V.cholerae* isolates to antibiotics [49]. The antibacterial activity of AgNPs against *V.cholerae* was confirmed in some other studies but the reported values were different from those obtained in the present study. Such differences could probably be explained by the differences in the *V.cholerae* isolates tested, or may be attributed to the differences in the NPs synthesis method and nature of NPs used such as size, shape and stabilizing agents as mentioned by [50,51]. In study of [52] the inhibition diameter of $AgNO_3$ against *V.cholerae* was recorded at 17mm and this result agree with the present study. The low concentrations of Ag induce leakage *in Vibrio cholerae* membrane, in complete deenergization and, cell death as mentioned by [53]. Also in this study found synthesized sliver nanoparticle from seed extract had antibacterial effect against *V.cholerae* and these results agreement with previous study that recorded inhibition diameter of seed extract of *Trigonella foenum-graecum* on *Streptococcus pneumoniae (15* mm) *Proteusvulgaris* 10mm, *pseudomonas aeruginosa* 14mm, *Staphylococcus aureues* 9 mm while diameter of seed extract of *Trigonella foenum-graecum* SNP 17mm, 12mm, 18mm, 11 mm respectively in study of [54]. *Trigonella foenum-graecum* (fenugreek seeds) Cu nanoparticles was reached 5 mm for *Pseudomonas aeruginosa*, 10mm zone of inhibition for *Bacillus subtilis* 10mm for *Agrobacteriumtumefaciens* 9 mm for *Proteus mirabilis* and while in study of [37].

The Silver nanoparticles (AgNPs) were synthesized using aqueous leaf extract of

Table 1. Show different susceptibility of *V.cholerae* to antibiotic alone and antibiotic synergistic with SNPS in Diameter of inhibitory zone.

Antibacterial	Diameter of inhibitory zone mm)	Antibacterial with SNPS	Diameter of inhibitory zone mm with SNPS
Silvernanoparticle (SNPS)	18	--------	--------
Levofloxacin	17	SNPs + Levofloxacin	24
Trimethoprime	10	SNPs +Trimethoprim	15
cefepime	14	SNPs +Cefepime	20
ceftazidime	12	SNPs +Ceftaezidime	16
Ampicillin	12	SNPs +Ampicillin	20
Gentamicin	10	SNPs + Gentamicin	15
P-value	4.027 *	P-value	5.178 *

* (P≤0.05).

Trigonella foenumgraecum and found the zone of inhibition was recorded 9 mm *for Escherichia coli* O157:H7 and *Staphyl ococcus aureus.* Also, [38] performed effect of silver nanoparticles *from water extract of Trigonella foenumgraecum* and found the Zone of inhibition of AgNP for *S. aureus* was 18mm, *B. subtilis* 22*mm, MRSA* 14*mm, E. coli* 8mm, *P. aeroginosa* 12mm and *K. pneumoniae* 25 mm. On the other hand, the antibacterial activity of synthesized AgNPs leaf extract of *Trigonella foenumgraecum* was then tested on *S. aureus, E. coli, P. aeruginosa and V. cholerae* which showed an inhibition zone of 6, 12, 11 mm respectively as documented by [39]. The antimicrobial effect can be due to disruption in bacterial cell wall, generation of ROS, and release of Ag+ [55]. Therefore, their synergistic activity with different antimicrobials may be due more mechanisms. Gram-negative bacteria are with an outer membrane of lipopolysaccharide (LPS), which act as a layer limits penetration of antimicrobials with large molecular weights [56].so AgNPs due to its reduced size, entered inside the cells of bacteria and effect on respiration process or by triggering cell membrane damage [57]. According to the previous studies the presence of different compounds in seeds of plant act as the reducing agent and form the stabilized AgNPs [58]. Most microorganism have shown silver ions to be highly toxic., Interference in DNA replication and inactivating proteins. Leading to bacterial death [59]. AgNPs and antibiotics combinations limit antibiotic resistance and dose requirements for treatment [60]. The bactericidal effect of silver nanoparticles was determined (*V.cholerae* -Levo) Levofloxacin have greater antibacterial activity. And enhanced antibacterial activity of AgNPs- Levo [61]. Combining nanometrial with antimicrobials minimize toxicity and reducing the requirement for high-dosage regimens [62]. studies found that AgNP- combinations make pathogens susceptible to ampicillin and ciprofloxacin, with significant changes in antibacterial activities and structural properties [63,64].

CONCLUSION

The purpose of this work was to evaluate the antibacterial impact of fenugreek seed extract-synthesised AgNPs.AgNPs were found to be efficient against *V. cholerae*, and fenugreek seed extract is thought to be a more potent antibacterial with a low cost of production that is also environmentally to AgNP synthesis.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

REFERENCES

1. Tenorio JCB. Discussing One Health: Veterinary Public Health, Health Communication, and Collaborations and Partnerships. Advances in Animal and Veterinary Sciences. 2022;10(4).
2. R.Abdul F, A.Taher N, S. Hassan A, H. Batah E. The Effect of Coumarin Derivatives(compounds) on the Vibrio cholerae Isolates from Different Clinical Iraqi Sources. Iraqi Journal of Pharmaceutical Sciences (P-ISSN: 1683 - 3597 , E-ISSN : 2521 - 3512). 2017;26(1):32-39.
3. Al-Obaidi MJL. Survey study on Cholera Disease in South Baghdad. Baghdad Science Journal. 2012;9(2):214-219.
4. Al-Fatlawy HNK, Aldahhan HA, Alsaadi AH. Phylogenetic of ERIC-DNA Fingerprinting and New Sequencing of Aeromonas Species and V. Cholerae DNA. American Journal of Applied Sciences. 2017;14(10):955-964.
5. A Histological Study on the Effect of Vibrio Cholerae And Its Enterotoxin on Pregnant Mice. Minar International Journal of Applied Sciences and Technology. 2024;06(03).
6. Ali MR, Bayati SM, Mahmood MB, Mohammed AA. In vitro study of curcumin calcium carbonate phosphate nanoparticles (Curcumin-NPs) impacts on the meriz goat's coccidian oocysts. Iraqi Journal of Veterinary Sciences. 2022;36(3):809-814.
7. Al-Jubouri AK, Al-Saadi NH, Kadhim MA. Anti- Inflammatory and Anti- Bacterial Activity of Copper Nanoparticles Synthesized From Myrtus Communis Leaves Extract. Iraqi Journal of Agricultural Sciences. 2022;53(3):698-711.
8. Riwad MT, Alag MK. Role of Nano and Metallic Boron Foliar Nutrition on Water Stress Reducing in Sweet Corn Yield and Its Components. Iraqi Journal of Agricultural Sciences. 2023;54(5):1421-1432.
9. Al-Dujaily AH, Mahmood AK. Evaluation of Antibacterial and Antibiofilm Activity of Biogenic Silver Nanoparticles and Gentamicin Against Staphylococcus aureus Isolated from Caprine Mastitis. The Iraqi Journal of Veterinary Medicine. 2022;46(1):10-16.
10. Ahmed MH, Omran ZS. Effect Of CuO Nanoparticles on Seed Germination and Seedling Growth in Echinacea Purpurea In Vitro. Iraqi Journal of Agricultural Sciences. 2024;55(Special):34-42.
11. Al-Zyadi AJH. The therapeutic role of alcoholic extract of fenugreek seeds on hypothyroidism state induced by thiourea and some blood parameters in adult male rabbits. The Iraqi Journal of Veterinary Medicine. 2015;39(1):1-7.
12. Hasanain NE. Effect of Supplementation Fenugreek Oil to The Diet on the Physiological, Anatomical and Histological Traits of Broilers. Iraqi Journal of Agricultural Sciences.

2023;54(1):106-113.
13. Masara Dj, Neamah Si. Effect Of Chemical Media Components And Silver Nanoparticles On The Induction Of Callus Culture And Accumulation of Secondary Compounds in a Trigonella foenum-graecum L. Iraqi Journal Of Agricultural Sciences. 2024;55(Special):111-121.
14. Salim Al-Shmgani H, Ashij MA, Khalil KAA, Mohammed HA. Synthesis and Characterization of Proteolytic Enzyme Loaded on Silver Nanoparticles. Ibn AL-Haitham Journal For Pure and Applied Sciences. 2024;37(1):43-53.
15. Ai-Mayah AAS. Effect Of Garlic (Allium Sativum) And Fenugreek (Trigonella Foenum-Graecum) Extracts On Aspergillus Fumigatus. The Iraqi Journal of Veterinary Medicine. 2005;29(1):137-142.
16. Al-Qayim MA. EFFECTS OF FENUGREEK SEED ON HEPATIC CELLULAR FUNCTION'S IN LAYING HENS. The Iraqi Journal of Veterinary Medicine. 2000;24(2):196-211.
17. Mohammed LS. Effect of different heat treatments on fenugreek seed proteins (Trigonella foenum-graecum L.). Biochemical and Cellular Archives. 2022:3851-3856.
18. Suhail RN, Mustafa SA, Al-Obodi EE. Effeciency Of Silver Nanoparticales as Antibacterial Against Aeromonas Hydrophila Isolated from Infected Common Carp. Iraqi Journal of Agricultural Sciences. 2022;53(3):589-597.
19. Saeed AA, Abdulwahid MT. Effect of Zinc Oxide Nanoparticles Synthesis by (Zingiber Officinale) Ginger Extract in Some Microbiological Quality of Fresh Chicken Meat During Referginated Storage. Al-Anbar Journal of Veterinary Sciences. 2022;15(1).
20. Dawood TN, Al-Aaraji AS, Abood DA. Stereological and Histopathological Effects of Trigonella foenum-graecum Seeds on Rabbits Ovary. The Iraqi Journal of Veterinary Medicine. 2020;44((E0)):29-33.
21. Pal D, Mukherjee S. Fenugreek (Trigonella foenum) Seeds in Health and Nutrition. Nuts and Seeds in Health and Disease Prevention: Elsevier; 2020. p. 161-170. http://dx.doi.org/10.1016/b978-0-12-818553-7.00013-9
22. Varghese R, Almalki MA, Ilavenil S, Rebecca J, Choi KC. Silver nanopaticles synthesized using the seed extract of Trigonella foenum-graecum L. and their antimicrobial mechanism and anticancer properties. Saudi J Biol Sci. 2019;26(1):148-154.
23. Байректаревич А. From WWI to www. – PUT(-)IN Next Door. Международные отношения. 2015;1(1):32-35.
24. Martínez-Murcia A, Beaz-Hidalgo R, Navarro A, Carvalho MJ, Aravena-Román M, Correia A, et al. Aeromonas lusitana sp. nov., Isolated from Untreated Water and Vegetables. Curr Microbiol. 2016;72(6):795-803.
25. Al-Jubouri AK, Al-Saadi NH, Kadhim MA. Green Synthesis of Copper Nanoparticles From Myrtus Communis Leaves Extract: Characterizattion, Antioxidant And Catalytic Activity. Iraqi Journal of Agricultural Sciences. 2022;53(2):471-486.
26. Hojjat SS, Hojjat H. Effect of Nano Silver on Seed Germination and Seedling Growth in Fenugreek Seed. ETP International Journal of Food Engineering. 2015;1(2).
27. Ranjan R, Prasad SM. XRD analysis of nanoparticles synthesized using aqueous and alcoholic extracts of Cuscuta reflexa. Balneo and PRM Research Journal. 2023(Vol.14, no.3):585.
28. Abbas M, Yassein S. Comparison Between Conventional and Molecular Identification of Vibrio Cholerae Isolated From Human and Birds. Egyptian Journal of Veterinary Sciences. 2025;56(2):377-383.
29. Goyal S, Gupta N, Kumar A, Chatterjee S, Nimesh S. Antibacterial, anticancer and antioxidant potential of silver nanoparticles engineered using Trigonella foenum-graecum seed extract. IET Nanobiotechnology. 2018;12(4):526-533.
30. Tameemi AIA-, Masarudin MJ, Rahim RA, Timms V, Neilan B, Isa NM. Antibacterial Properties of Zinc Oxide Nanoparticles Synthesized by the Supernatant of Weissella Confusa Upm22mt04. Iraqi Journal of Agricultural Sciences. 2023;54(5):1209-1222.
31. Aljeldah MM. Antimicrobial Resistance and Its Spread Is a Global Threat. Antibiotics. 2022;11(8):1082.
32. Fayaz AM, Balaji K, Girilal M, Yadav R, Kalaichelvan PT, Venketesan R. Biogenic synthesis of silver nanoparticles and their synergistic effect with antibiotics: a study against gram-positive and gram-negative bacteria. Nanomed Nanotechnol Biol Med. 2010;6(1):103-109.
33. Performing Statistical Analyses in SAS Enterprise Guide. Data Analysis Using SAS Enterprise Guide: Cambridge University Press; 2009. p. 25-31. http://dx.doi.org/10.1017/cbo9780511804786.004
34. Singh RP, Magesh S, Rakkiyappan C. Study of colloids of Ag nanoparticles from Mentha Piperita leaf extract and their antibacterial effect. 2011 11th IEEE International Conference on Nanotechnology; 2011/08: IEEE; 2011. p. 57-60.
35. Van Dong P, Ha CH, Binh LT, Kasbohm J. Chemical synthesis and antibacterial activity of novel-shaped silver nanoparticles. International Nano Letters. 2012;2(1).
36. B Kadam V. Seasonal Variations in Primary Metabolites and their Statistical Analysis in Trigonella foenum-graecum. International Journal of Science and Research (IJSR). 2025:1600-1602.
37. Rajkumar T, Patra JK. A green approach for the biosynthesis of powdered silver nanoparticles using leaf extract of Trigonella foenum-graecum L.: Characterization and antibacterial evaluation. Bangladesh Journal of Botany. 2019;48(3):427-436.
38. Alwhibi MS, Soliman DA, Awad MA, Rizwana H, Marraiki NA. Biosynthesis of Silver Nanoparticles Using Fenugreek Seed Extract and Evaluation of Their Antifungal and Antibacterial Activities. Journal of Computational and Theoretical Nanoscience. 2018;15(4):1255-1260.
39. Ghoshal G, Singh M. Characterization of silver nanoparticles synthesized using fenugreek leave extract and its antibacterial activity. Materials Science for Energy Technologies. 2022;5:22-29.
40. Ghafarzadegan R, Yaghoobi M, Momtaz S, Ashoory N, Ghiaci Yekta M, Hajiaghaee R. Process optimization for green synthesis of iron nanoparticles by extract of fenugreek (Trigonella foenum-graecum L.) seeds. Journal of Medicinal Plants. 2022;21(81):22-32.
41. Aldoori A, Samawi F, noori A, Ahmed K. Vibrio Cholera 22: Isolation and Molecular Detection of Cholera Toxin (CTX) in Some Iraqi Governorates. 5th International Conference on Biomedical and Health Sciences: Cihan University-Erbil; 2024. p. 391-395.
42. Aziz Naji Al-Hadrawi H, Abdulabass Al-Harmoosh R, Mahdi Alabassi M, Natiq Kabroot Al-Fatlawy H. Isolation and Identification of Shigella dysenteriae from patients in Najaf Province / Iraq. Al-Kufa University Journal for Biology. 2017;9(1):7-12.
43. Al Taee AMR, Khamees NR, Shammari NAHA. Vibrio Species Isolated from Farmed Fish in Basra City in Iraq. Journal of Aquaculture Research and Development. 2017;08(02).

44. Abdulabbas HT, Bunyan IA, Abdul-Lateef LA. Isolation and Genotyping of Vibrio Cholerae Isolates from Patients with Cholera Disease in Babylon Province. Annals of Tropical Medicine and Public Health. 2019;22(08):45-59.
45. Qamar K, Malik UU, Yousuf J, Essar MY, Muzzamil M, Hashim HT, et al. Rise of cholera in Iraq: A rising concern. Annals of Medicine and Surgery. 2022;81.
46. Abdallah M, Benoliel C, Jama C, Drider D, Dhulster P, Chihib N-E. Thermodynamic Prediction of Growth Temperature Dependence in the Adhesion of Pseudomonas aeruginosa and Staphylococcus aureus to Stainless Steel and Polycarbonate. J Food Prot. 2014;77(7):1116-1126.
47. Masoud EM, El-Bellihi AA, Bayoumy WA, Mohamed EA. Polymer composite containing nano magnesium oxide filler and lithiumtriflate salt: An efficient polymer electrolyte for lithium ion batteries application. J Mol Liq. 2018;260:237-244.
48. Ibrahim E, Fouad H, Zhang M, Zhang Y, Qiu W, Yan C, et al. Biosynthesis of silver nanoparticles using endophytic bacteria and their role in inhibition of rice pathogenic bacteria and plant growth promotion. RSC Advances. 2019;9(50):29293-29299.
49. Verma J, Bag S, Saha B, Kumar P, Ghosh TS, Dayal M, et al. Genomic plasticity associated with antimicrobial resistance in Vibrio cholerae. Proceedings of the National Academy of Sciences. 2019;116(13):6226-6231.
50. Dong Y, Zhu H, Shen Y, Zhang W, Zhang L. Antibacterial activity of silver nanoparticles of different particle size against Vibrio Natriegens. PLoS One. 2019;14(9):e0222322.
51. Rizwana H, Alwhibi MS, Aldarsone HA, Awad MA, Soliman DA, Bhat RS. Green synthesis, characterization, and antimicrobial activity of silver nanoparticles prepared using Trigonella foenum-graecum L. leaves grown in Saudi Arabia. Green Processing and Synthesis. 2021;10(1):421-429.
52. Keshari AK, Srivastava R, Singh P, Yadav VB, Nath G. Antioxidant and antibacterial activity of silver nanoparticles synthesized by Cestrum nocturnum. J Ayurveda Integr Med. 2020;11(1):37-44.
53. Dibrov P, Dzioba J, Gosink KK, Häse CC. Chemiosmotic Mechanism of Antimicrobial Activity of Ag^{+} in Vibrio cholerae. Antimicrobial Agents and Chemotherapy. 2002;46(8):2668-2670.
54. Khan TM, Wu DBC, Dolzhenko AV. Effectiveness of fenugreek as a galactagogue: A network meta-analysis. Phytother Res. 2017;32(3):402-412.
55. Bruna T, Maldonado-Bravo F, Jara P, Caro N. Silver Nanoparticles and Their Antibacterial Applications. Int J Mol Sci. 2021;22(13):7202.
56. Vidaillac C, Gardete S, Tewhey R, Sakoulas G, Kaatz GW, Rose WE, et al. Alternative Mutational Pathways to Intermediate Resistance to Vancomycin in Methicillin-Resistant Staphylococcus aureus. The Journal of Infectious Diseases. 2013;208(1):67-74.
57. Swamy MK, Akhtar MS, Mohanty SK, Sinniah UR. Synthesis and characterization of silver nanoparticles using fruit extract of Momordica cymbalaria and assessment of their in vitro antimicrobial, antioxidant and cytotoxicity activities. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. 2015;151:939-944.
58. Iravani S. Green synthesis of metal nanoparticles using plants. Green Chem. 2011;13(10):2638.
59. Kora AJ, Rastogi L. Enhancement of Antibacterial Activity of Capped Silver Nanoparticles in Combination with Antibiotics, on Model Gram-Negative and Gram-Positive Bacteria. Bioinorg Chem Appl. 2013;2013:1-7.
60. Abo-Shama UH, El-Gendy H, Mousa WS, Hamouda RA, Yousuf WE, Hetta HF, et al. Synergistic and Antagonistic Effects of Metal Nanoparticles in Combination with Antibiotics Against Some Reference Strains of Pathogenic Microorganisms. Infection and Drug Resistance. 2020;Volume 13:351-362.
61. Keshari T, Yadav VK, Srivastava VP, Yadav LDS. Visible light organophotoredox catalysis: a general approach to β-keto sulfoxidation of alkenes. Green Chem. 2014;16(8):3986.
62. Baptista PV, McCusker MP, Carvalho A, Ferreira DA, Mohan NM, Martins M, et al. Nano-Strategies to Fight Multidrug Resistant Bacteria—"A Battle of the Titans". Front Microbiol. 2018;9.
63. Lopez-Carrizales M, Velasco KI, Castillo C, Flores A, Magaña M, Martinez-Castanon GA, et al. In Vitro Synergism of Silver Nanoparticles with Antibiotics as an Alternative Treatment in Multiresistant Uropathogens. Antibiotics. 2018;7(2):50.
64. Zahraa HH, Rasheed HA. Cytotoxic Effect of Asparaginase Produce from E. Coli and Conjugated with Zno Nanoparticles on Cancer Cell Lines. Iraqi Journal of Agricultural Sciences. 2023;54(6):1664-1678.